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A behavioural economics analysis of the impact of information and knowledge on CO_2 capture and storage acceptance in the European Union

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Abstract

The paper analyses the impact that European Union citizens' access to information on climate change has on their awareness of carbon capture and storage (CCS), perceived risks and benefits of using CCS and stated choice of preferred CCS options. We use a Eurobarometer dataset about awareness/acceptance of CCS and run structural equation models (SEM) for twelve EU countries with an average sample size of 1,100 observations per country. Results between the different countries are comparable and, alongside other determinants, access to information sources will significantly impact CCS awareness, perceived risk and benefits of CCS and preferences towards options of CCS.

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***Keywords*: CO_2 capture and storage; information and knowledge; EU citizens' CCS acceptance; structural equation models; behavioural economics.**

1. Introduction

CO_2 capture and storage (CCS) is a set of technologies that facilitates the reduction of CO_2 emissions from coal-based electricity production. In order for CCS to be utilised on a large scale, there is a need for its public acceptance. Based on the results of several studies, it is believed that the CCS awareness of the majority of public is largely non-existent and therefore it cannot genuinely decide whether it is for or against CCS

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(Schumann & Simon, 2009). A number of studies have analysed the impact of information on public awareness and perceptions of CCS (Schumann & Simon, 2009; Best-Waldhobera & Daamena, 2011; Alphen et al., 2007; Huijts et al., 2007; Itaoka et al., 2009). Most studies found that information is a key factor influencing public's CCS awareness and perceptions, however, despite increased communication to public, CCS awareness level is still low and better communication strategies are needed.

The paper analyses the impact that the European Union (EU) citizens' access to information on climate change (amongst other a priori determinants) has on their awareness of CCS, perceived risks and benefits of using CCS and stated choice of preferred CCS options.

2. Material and methods

2.1. Data

The data used in this study were extracted from the Dataset Eurobarometer 75.1: Public Awareness and Acceptance of CO_2 Capture and Storage. The Eurobarometer survey was carried out by TNS Opinion & Social by face-to-face interviews with European Union (EU) citizens in February-March 2011 (Eurobarometer, 2011). The original database includes data on access to and trust in climate change information; perceived climate change priorities for the European Union; knowledge about CO_2, its main sources; perceived impact of CO2 emissions on climate change; awareness of carbon capture and storage; awareness of energy production aspects; perceptions as regards use of energy sources; perceptions as regards effectiveness of CCS to fight climate change; perceived personal benefit of using CCS technology; risk perceptions; preferred CO_2 storage options; CCS attitudes; and socio-demographic data (political orientation, marital status, education, gender, age, occupation, type of community, number of children).

We analysed the datasets for twelve countries (United Kingdom, Bulgaria, Czech Republic, Germany, Greece, Spain, Finland, France, Italy, Netherlands, Poland and Romania). The countries have a good geographical coverage (Western, Northern, Southern and Central-Eastern Europe) and include old and new European Union (EU) member countries. The average sample size is 1,100 observations per country, ranging from 1,000 observations in Greece and Poland to 1,622 observations in Germany. The variables included in the analysis are socio-demographic (education and number of children living in the household) and climate change related (access to information, CCS awareness, perceptions of CCS effectiveness, benefits and risks, and preferred CCS options).

2.2. Structural equation modelling

We use structural equation models (SEM) with observed and latent variables to test the influence of a priori identified determinants on CCS perceptions. SEM is a statistical technique for testing and estimating causal relationships amongst variables, some of which may be latent, based on a combination of statistical data and qualitative causal assumptions. Latent variables are not directly observed but inferred from other variables that are observed and directly measurable (Bollen, 1989). Examples of latent variables are constructs like extraversion, spatial ability, self-efficacy, and attitudes (Borsboom, 2003). While the idea of causality may be controversial (Mueller, 1996), SEM is not intended to discover causes but to assess the soundness of the causal relationships a priori identified in the scientific literature. Hence it is mostly used as a confirmatory analysis/theory testing tool.

The basic SEM consists of two parts, namely the measurement model (which specifies the relationships between the latent variables and their constituent indicators), and the structural model (which designates the causal relationships between the latent variables). The measurement model is similar to factor analysis, where latent variables represent ‘shared’ variance, or the degree to which indicators ‘move’ together. The structural model is similar to a system of simultaneous regressions, with the difference that in SEM some variables can be dependent in some equations and independent in others. The model is defined by the following system of three equations in matrix terms (Jöreskog and Sörbom, 2007):

The structural equation model: $$\eta = B\eta + \Gamma\xi + \zeta \quad (1)$$

The measurement model for y: $$y = \Lambda_y \eta + \varepsilon \quad (2)$$

The measurement model for x: $$x = \Lambda_x \xi + \delta \quad (3)$$

Where: η is an m*1 random vector of endogenous latent variables; ξ is an n*1 random vector of exogenous latent variables; B is an m*m matrix of coefficients of the η variables in the structural model; Γ is an m*n matrix of coefficients of the ξ variables in the structural model; ζ is an m*1 vector of equation errors (random disturbances) in the structural model; y is a p*1 vector of endogenous variables; x is a q*1 vector of predictors or exogenous variables; Λ_y is a p*m matrix of coefficients of the regression of y on η; Λ_x is a q*n matrix of coefficients of the regression of x on ξ ; ε is a p*1 vector of measurement errors in y; δ is a q*1 vector of measurement errors in x.

This study estimates SEM with the normal-theory maximum likelihood (MLE) method using the statistical package Lisrel 8.80 (Jöreskog and Sörbom, 2007).

2.3. Latent variables and indicators

Eleven latent variables were identified and extracted in each of the twelve models, expressing the preferred CCS options and the underlying determining factors (educational level; number of children younger than 14 years old living in the household; perceived level of information on climate change; access to information sources on climate change; CCS awareness; CCS project awareness; perceptions as regards effectiveness of CCS to fight climate change; perceived personal benefit of using CCS technology in own region; perceptions as regards the hypothesis of having a deep underground storage site for CO_2 within five kilometres of own home; involvement in decision-making process regarding the creation of an underground CO_2 storage site near own home; preferred CO_2 storage options as regards future use of CCS in the EU). Table 1 presents a description of the latent variables and their corresponding indicators.

Table 1. Description of latent variables and their corresponding indicators

Latent variable	Indicator	Statement	Value & label	Variable type
educs	educ	education	1 = no full-time education; 2 = in full-time education until the age of 15 years old; 3 = in full-time education until the age of 16-19 years old; 4 = in full-time education after the age of 20 years old; 5 = still studying	categorical

child	children	number of chidren (14 years old and younger) living in the household	0 = none; 1 = one child; 2 = two children; 3 = three children; 4 = four or more children	categorical
	infcause	perceived level of information about the different causes of climate change	1 = not at all informed; 2 = not very well informed; 3 = fairly well informed; 4 = very well informed	ordinal
info	infconsq	perceived level of information about the different consequences of climate change	1 = not at all informed; 2 = not very well informed; 3 = fairly well informed; 4 = very well informed	ordinal
	infight	perceived level of information about ways in which we can fight climate change	1 = not at all informed; 2 = not very well informed; 3 = fairly well informed; 4 = very well informed	ordinal
infaccs	infacc	access to information sources on climate change (TV, radio, internet, newspapers, magazines, friends/family, school/university)	0 = no sources; 1 = one source; 2 = two sources; 3 = three sources; 4 = four sources; 5 = five sources; 6 = six sources; 7 = seven sources	categorical
ccsawar	ccsaware	CCS awareness (have you ever heard of CO2 capture and storage, also known as carbon capture and storage or carbon capture and sequestration (CCS)?)	1 = no; 2 = yes, but you do not really know what it is; 3 = yes, and you know what it is	categorical
ccsprojs	ccsproj	CCS project awareness (have you ever heard of a CCS project in your country?)	1 = no; 2 = yes	dichotomous
effect	effectiv	perceptions as regards effectiveness of CCS to fight climate change	1 = not at all effective; 2 = not very effective; 3 = fairly effective; 4 = very effective	ordinal
benefits	benefit	perceived personal benefit of using CCS technology in own region	1 = would not benefit; 2 = would benefit	dichotomous
worrys	worry	perceptions as regards the hypothesis of having a deep underground storage site for CO2 within 5km of own home	1 = not at all concerned; 2 = not very concerned; 3 = fairly concerned; 4 = very concerned	ordinal
preferhs	preferh	involvement in decision-making process regarding the creation of an underground CO2 storage site near own home	0 = otherwise; 1 = you would like to be directly consulted and to participate in decision-making process	dichotomous
prefergs	preferg	preferred CO2 storage options as regards future use of CCS in the EU	0 = don't mind, no preferences; 1 = offshore, under the seabed; 2 = underground and onshore, but near the power plant; 3 = underground and onshore, but only where human population is very low	categorical

Ten of the eleven latent variables are built in the model as single-indicator variables for the following reasons: (1) variables ‘educs’, ‘child’ and ‘infaccs’ are observed variables built as single-indicator latent variables as specified by the software used (Lisrel8.80); (2) variables ‘ccsawar’, ‘ccsprojs’, ‘effect’, ‘benefits’, ‘worrys’, ‘preferhs’ and ‘prefergs’ are single-indicator latent variables as their indicators state the exact intended meaning of the chosen latent variables. Latent variable ‘info’ was built based on three indicators, namely ‘infcause’ (perceived level of information about the different causes of climate change), ‘infconsq’ (perceived level of information about the different consequences of climate change), ‘infight’ (perceived level of information about ways in which we can fight climate change).

Table 2 presents a series of descriptive statistics for the indicators of the latent variables included in the twelve models.

Table 2. Descriptive statistics

	UK		BG		CZ		DE		EL		ES		FI		FR		IT		NL		PL		RO	
	Mean	StdD	Mean	StdD	Mean	StdD	Mean	StdD	Mean	StdD	Mean	StdD	Mean	StdD	Mean	StdD	Mean	StdD	Mean	StdD	Mean	StdD	Mean	StdD
educ	2.98	.921	3.18	.811	3.18	.783	3.16	.844	3.12	.948	2.91	1.027	3.47	1.023	3.25	.887	3.01	1.044	3.66	.744	3.19	1.028	3.29	.797
children	.46	.89	.4	.755	.41	.776	.31	.703	.34	.693	.46	.798	.39	.835	.48	.922	.43	.779	.43	.843	.46	.845	.33	.666
infcause	2.63	.867	2.05	.823	2.21	.744	2.51	.81	2.31	.834	2.22	.862	2.63	.704	2.59	.821	2.06	1.006	2.8	.802	2.14	.837	1.95	.876
infconsq	2.64	0.856	2.09	.846	2.2	.76	2.53	.815	2.34	.846	2.22	.856	2.66	.683	2.58	.805	2.08	1.012	2.77	.795	2.16	.842	1.94	.898
infight	2.63	.873	1.9	.804	2.18	.758	2.42	.816	2.25	.812	2.19	.869	2.66	.694	2.54	.829	1.99	.977	2.73	.803	2.08	.84	1.84	.908
infacc	2.32	1.44	1.95	1.135	2.28	1.447	2.75	1.476	2.32	1.34	1.86	1.244	2.95	1.335	2.63	1.341	1.88	1.24	3.13	1.392	1.91	1.312	2	1.253
ccsaware	1.31	.729	1.18	.638	1.29	.586	1.45	.777	1.29	.582	1.17	.581	1.42	.704	1.32	.631	1.21	.697	2.39	.768	1.19	.615	1.2	.661
ccsproj	1.03	.27					1.08	.361			.99	.212					.98	.449	1.36	.505	1.06	.31		
effectiv	1.77	1.445	1.66	1.567	2.12	1.328	1.35	1.293	2.2	1.233	1.75	1.421	1.98	1.185	1.59	1.308	1.66	1.418	2.18	1.162	1.77	1.453	1.55	1.619
benefit	.9	.821	.81	.894	1.1	.747	.72	.637	1.1	.682	.94	.811	.99	.647	.8	.711	.76	.811	.94	.562	.91	.852	.74	.875
worry	2.26	1.387	2.81	1.326	2.81	1.166	2.43	1.368	3.2	.942	2.66	1.326	2.25	1.24	2.76	1.218	2.44	1.388	2.46	1.078	2.29	1.38	2.36	1.459
prefer	.4	.489	.37	.484	.29	.453	.49	.5	.45	.498	.37	.483	.28	.45	.41	.492	.29	.453	.41	.492	.35	.476	.44	.497
preferg	1.25	1.073	1.25	1.168	1.63	1.112	1.19	1.15	1.31	1.129	1.48	1.218	1.77	1.124	1.42	1.173	1.19	1.234	1.14	1.017	1.34	1.268	1.24	1.189
Sample Size	1322		1001		1014		1622		1000		1004		1001		1035		1027		1012		1000		1053	

3. Results

The conceptual diagram is presented in Figure 1.

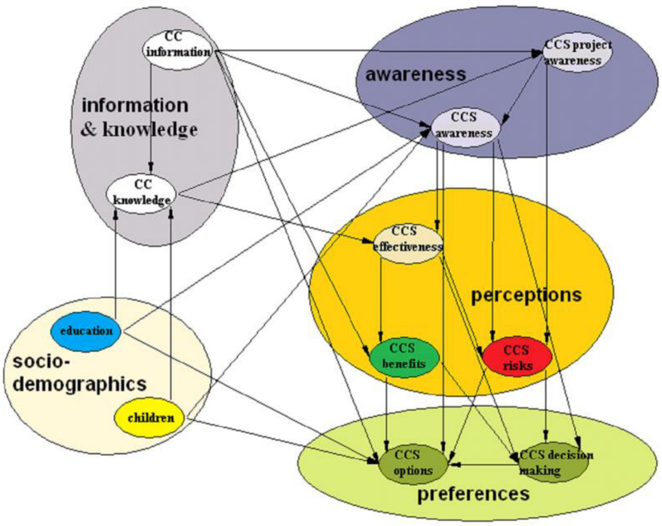

Fig. 1. Conceptual diagram

We tested the twelve models and the path diagrams for the estimated models are available from the authors upon request. All twelve models have a very good fit according to the measures of absolute, incremental and parsimonious fit (Hair et al., 2006). The main goodness of fit (GoF) indicators (estimated and recommended values) for the estimated models are presented in Table 3.

Table 3. Goodness of fit indicators

GoF indicators	UK	BG	CZ	DE	EL	ES	FI	FR	IT	NL	PO	RO	Recommended value
Normed chi-square	2.35	1.90	2.96	2.32	2.21	1.57	2.88	2.29	1.84	2.34	1.67	2.94	[1-3]
Root Mean Square Error of Approximation	0.032	0.03	0.044	0.029	0.035	0.024	0.043	0.035	0.029	0.036	0.026	0.046	0.00-0.10
P-Value Test Close Fit (RMSEA<0.05)	1	1	0.85	1	1	1	0.86	0.99	1	1	1	0.79	0.50-1.00
Normed Fit Index	0.99	0.99	0.97	0.99	0.98	0.99	0.98	0.98	0.99	0.97	0.99	0.98	0.90-1.00
Non-Normed Fit Index	0.99	0.99	0.97	0.99	0.98	0.99	0.97	0.98	0.99	0.97	0.99	0.98	0.90-1.00
Comparative Fit Index	0.99	0.99	0.98	0.99	0.99	1.00	0.98	0.99	1.00	0.98	1.00	0.99	0.90-1.00
Incremental Fit Index	0.99	0.99	0.98	0.99	0.99	1.00	0.98	0.99	1.00	0.98	1.00	0.99	0.90-1.00
Relative Fit Index	0.98	0.98	0.95	0.98	0.97	0.98	0.96	0.96	0.98	0.95	0.98	0.97	0.90-1.00
Standardised Root Mean Square Residual	0.023	0.019	0.025	0.018	0.021	0.021	0.026	0.026	0.017	0.024	0.018	0.028	<0.08
Goodness of Fit Index	0.99	0.99	0.98	0.99	0.99	0.99	0.98	0.99	0.99	0.98	0.99	0.98	0.90-1.00
Adjusted Goodness of Fit Index	0.98	0.98	0.96	0.98	0.97	0.98	0.96	0.97	0.98	0.97	0.98	0.96	0.90-1.00

An acceptable level of overall goodness-of-fit does not guarantee that all constructs meet the requirements for the measurement and structural models. The validity of the SEM was assessed in a two-step procedure, the measurement model and the structural model.

In the measurement model we tested the reliability of the single-indicator latent variables, namely we tested the 'theory-testing extremes' of reliability within the range of 0.7 to 1 (Ping, 2008) and determined that none of the structural coefficients became non-significant at these extremes. The reliability of the single-indicator latent variables was assumed the value of 0.99 for variables 'educs', 'child', 'infaccs' 'ccsawar', 'ccsprojs' and 'benefits' with the corresponding loadings (square root of reliability value) of 0.99 on own indicators and standardised measurement error variance of 0.01; and value of 0.7 for 'effect', 'worrys', 'preferhs' and 'prefergs' with the corresponding loadings of 0.84 and standardised measurement error variance of 0.3.

After assessing the overall model and aspects of the measurement model, the standardised structural coefficients for both practical and theoretical implications were examined. Table 4 presents the standardised total effects between latent variables in each of the twelve models. All effects (socio-demographics, information and perceptions) on preferred CCS options are specified, while only effects of climate change information and CCS awareness are underlined for perceptions of CCS effectiveness, benefits and risks.

Table 4. Standardised total (direct and indirect) effects (t-values in parentheses)

Observed/ latent variables	Total effects on 'prefergs'											
	UK	BG	CZ	DE	EL	ES	FI	FR	IT	NL	PL	RO
educs	0.11	0.05	-0.10	-0.02	0.13	0.08	0.03	0.10	0.11	-0.09	0.11	0.06
	(4.38)	(6.38)	(-3.47)	(-0.83)	(4.12)	(5.55)	(3.55)	(3.30)	(5.73)	(-2.87)	(5.20)	(6.31)
child	-0.15	-0.01	0.05	-0.02	0.01	0.0	-0.13	-0.01	0.00	0.02	-0.02	0.05
	(-6.14)	(-2.19)	(1.87)	(-4.02)	(2.62)	(0.29)	(-4.62)	(-2.55)	(0.07)	(3.15)	(-1.41)	(2.04)
infaccs	0.06	0.16	0.11	0.16	0.05	0.16	0.03	0.05	0.13	0.07	0.20	0.10
	(2.35)	(9.06)	(5.56)	(6.59)	(5.54)	(5.37)	(2.01)	(4.94)	(8.06)	(2.37)	(6.98)	(7.73)
info	0.13	0.17	0.08	0.15	0.11	0.12	0.11	0.04	0.27	0.00	0.14	0.19
	(8.33)	(8.55)	(4.08)	(10.03)	(6.31)	(6.46)	(4.75)	(3.56)	(11.26)	(0.25)	(7.09)	(11.20)
ccsawar	0.20	0.13	0.17	0.11	0.08	0.09	0.01	0.04	0.09	0.13	0.05	0.17
	(5.86)	(7.74)	(8.81)	(8.56)	(5.05)	(6.55)	(0.36)	(2.91)	(2.81)	(4.01)	(1.33)	(10.17)
ccsprojs	0.18	-	-	0.01	-	0.09	-	-	0.03	-	0.14	-
	(8.92)			(2.89)		(6.01)			(2.42)		(5.36)	
effect	0.44	0.45	0.55	0.40	0.42	0.44	0.63	0.29	0.66	0.34	0.55	0.42
	(13.88)	(11.20)	(13.40)	(12.15)	(9.49)	(11.01)	(13.41)	(9.49)	(13.94)	(7.37)	(13.67)	(12.18)
benefits	0.18	-	0.16	-	-0.13	-	0.18	0.12	-0.21	0.04	0.03	0.46
	(5.66)		(3.07)		(-2.92)		(1.02)	(3.01)	(-3.00)	(1.05)	(2.03)	(12.12)
worrys	0.41	0.18	-	0.08	0.07	0.17	0.34	0.16	0.07	0.03	0.32	0.30
	(10.78)	(4.15)		(5.06)	(1.50)	(4.06)	(5.57)	(3.74)	(3.18)	(2.11)	(7.76)	(7.45)
preferhs	0.19	0.23	-	-	0.13	-	0.13	0.11	0.14	0.09	0.12	0.19
	(4.42)	(5.04)			(2.90)		(2.16)	(2.30)	(3.36)	(2.18)	(2.66)	(4.44)
R-square	0.47	0.31	0.33	0.23	0.23	0.27	0.50	0.18	0.47	0.15	0.51	0.39
	Total effects on 'preferhs'											
infaccs	0.08	0.10	0.06	0.12	0.02	0.18	0.13	0.15	0.22	0.01	0.18	0.09
	(6.66)	(6.65)	(4.34)	(9.18)	(2.82)	(6.07)	(4.53)	(4.82)	(7.18)	(2.51)	(5.86)	(5.88)
info	0.11	0.21	0.14	0.24	0.04	0.09	0.08	0.01	0.19	0.01	0.02	0.14
	(8.01)	(6.76)	(4.53)	(9.68)	(2.88)	(4.96)	(4.01)	(2.09)	(5.06)	(2.72)	(2.28)	(4.57)
ccsawar	0.17	0.01	-	0.04	-0.01	0.06	-0.06	-0.04	-0.01	-0.03	-0.02	0.06
	(4.98)	(3.25)		(5.28)	(-0.50)	(3.57)	(-3.05)	(-3.19)	(-0.95)	(-2.87)	(-2.61)	(1.96)
	Total effects on 'worrys'											
infaccs	0.06	0.13	-	0.08	0.00	0.10	0.03	0.08	0.22	0.02	0.05	0.16
	(5.82)	(8.08)		(6.69)	(0.14)	(6.03)	(2.81)	(2.30)	(7.29)	(2.63)	(5.46)	(5.27)
info	0.10	0.24	-	0.15	0.01	0.18	0.13	0.02	0.27	0.03	0.08	0.09
	(6.71)	(7.65)		(6.11)	(0.14)	(5.46)	(4.14)	(2.17)	(7.53)	(2.87)	(5.63)	(5.66)
ccsawar	-0.08	0.05	-	0.09	-0.14	0.13	-0.10	-0.11	0.04	-0.10	-0.04	0.08

	(-1.53)	(3.85)		(5.74)	(-4.08)	(3.73)	(-3.10)	(-3.48)	(3.25)	(-3.05)	(-1.71)	(5.63)
	Total effects on ‘benefits’											
infaccs	0.19	0.27	0.10	0.12	0.02	0.18	0.12	0.06	0.23	0.08	0.13	0.12
	(8.48)	(9.97)	(3.23)	(9.20)	(0.62)	(6.92)	(4.50)	(5.47)	(8.95)	(5.92)	(7.83)	(8.31)
info	0.20	0.22	0.13	0.20	0.22	0.20	0.16	0.11	0.39	0.20	0.21	0.39
	(7.34)	(7.12)	(4.21)	(7.99)	(8.73)	(6.20)	(5.88)	(4.83)	(13.55)	(6.25)	(7.26)	(14.24)
ccsawar	0.33	0.27	0.28	0.24	0.13	0.16	0.24	0.19	0.24	0.24	0.05	0.36
	(12.61)	(10.02)	(10.43)	(10.96)	(5.31)	(6.87)	(8.75)	(5.91)	(8.80)	(7.60)	(1.22)	(13.74)
	Total effects on ‘ccsawar’											
infaccs	0.31	0.25	0.21	0.28	0.10	0.28	0.16	0.22	0.16	0.16	0.27	0.08
	(11.63)	(7.78)	(6.91)	(11.88)	(6.80)	(9.22)	(5.04)	(6.92)	(7.73)	(5.19)	(8.68)	(6.56)
info	0.27	0.23	0.22	0.35	0.26	0.35	0.29	0.27	0.40	0.28	0.19	0.27
	(9.04)	(6.33)	(6.21)	(13.00)	(7.84)	(9.39)	(8.35)	(7.87)	(13.07)	(8.41)	(5.82)	(8.56)

Table 4 shows that most variables have statistically significant coefficients in all models. Variable ‘educs’ does not significantly influence ‘prefergs’ in one of the twelve models (Germany); ‘child’ does not significantly influence ‘prefergs’ in four models (Czech Republic, Spain, Italy and Poland); ‘info’ does not significantly influence ‘prefergs’ in one model (The Netherlands); ‘ccsawar’ does not significantly influence ‘prefergs’ in two models (Finland and Poland); ‘benefits’ does not significantly influence ‘prefergs’ in two models (Finland and Netherlands); ‘worrys’ does not significantly influence ‘prefergs’ in one model (Greece).

Four of the models predict around 50% of the variance in preferred CCS options (i.e., 47% in United Kingdom, 50% in Finland, 47% in Italy and 51% in Poland), three of them predict between 30-40% of the variance (i.e., 39% in Romania, 31% in Bulgaria and 33% in Czech Republic), three of them predict around 25% of the variance (i.e., 23% in Germany, 23% in Greece and 27% in Spain), and two of them show lower values (i.e., 18% in France and 15% in Netherlands).

Overall, the ranking of determinants’ impact on preferred CCS options differs between models, however access to information sources and perceived level of information on climate change, followed by CCS awareness are among the strongest determinants in most models.

4. Discussion and conclusions

Our findings as regards the significant impact of access to and perceived level of climate change information on preferred CCS options confirm findings from the literature. Namely, the stronger the public’s access to more sources of climate change information and its perceived information level, the stronger its CCS awareness and ability to make an informed choice between CCS options. Additionally, more informed people will be more interested to be involved in CCS decision-making process (e.g., regarding the potential creation of an underground CO2 storage site near own home). The impact of information on perceptions of CCS benefits is also strong, much more so than its impact on perceptions of CCS risks. This might suggest that more informed people are more likely to perceive the benefits of using CCS as a means to fight climate change and have a more accurate understanding of potential risks.

Amongst other determinants, educational level significantly influences CCS perceptions in most models, however the magnitude of impact differs between models. This confirms findings from the literature, namely that more educated people are more likely to search for information and show stronger perceptions/behaviour towards climate change. The impact the number of children living in the household has on CCS perceptions is less straightforward. This determinant was not found significant in a third of the models, and shows contradictory influences. Some studies found that respondents with children are significantly more likely to fundamentally oppose CCS than their counterparts (Itaoka et al., 2009), however this is only confirmed in some of our models and the impact was found to be quite low.

CCS project awareness (included only in five models as this question was asked only of the citizens in United Kingdom, Germany, Spain, Italy and Poland, where such projects have been already implemented) has a significant effect in all models, suggesting that people aware of CCS projects are more able to make an informed choice between CCS options.

The results show that the ranking of determinants' impact on preferred CCS options differs between models, however access to information sources and perceived level of information on climate change, followed by CCS awareness are the strongest determinants in most models. These are only some of the factors influencing attitudes/perceptions, fact which is reflected in the level of variance explained in the models, nevertheless they signify the need for subsequent related actions targeted towards behavioural change.

This study aims to provide some information on the relationship between climate change attitudes/ perceptions and information/ awareness issues, amongst other determinants, in the European Union. As access to and perceived level of information together with CCS awareness were found to significantly influence CCS preferences, this might suggest the need for the European Union to invest more in enhancing the climate change information available to the public and improving access to it through measures such as climate change education campaigns. In recent years the amount of information on climate change issues available to public has increased considerably, however there is a need for 'ample, clear, sufficiently strong, and consistent signals' (Moser, 2010; Best-Waldhobera & Daamena, 2011).

There is an increasing amount of research on carbon dioxide (CO2) emissions and sinks, however the level of knowledge and information that the average citizen has on the topic is quite low. Climate change mitigation decision-making should involve participation at all levels and the public should always have a say in the process. As CO2 capture and storage (CCS) is an essential climate change mitigation technology, policy-makers should ensure an efficient knowledge transfer to the public and subsequently facilitate their informed response.

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References

Alphen, K., van, Voorst tot Voorst, Q. van, Hekkert, M.P., Smits, R.E.H.M. (2007). Societal acceptance of carbon capture and storage technologies. Energy Policy 35(8), 4368-4380.

Best-Waldhobera, M., Daamena, D. (2011). Development of CCS awareness and knowledge of the general public between 2004 and 2008. Energy Procedia 4 (2011) 6315–6321.

Bollen, K.A. (1989). Structural equations with latent variables. New York: John Wiley and Sons.

Eurobarometer, 2011. Dataset Eurobarometer 75.1: Public Awareness and Acceptance of CO2 Capture and Storage. European Commission, August 2011.

Hair, J. F., Black, W., Babin, B., Anderson, R.E., & Tatham, R.L. (2006). Multivariate data analysis. 6th edition, Upper Saddle River, NJ: Pearson Prentice Hall.

Huijts, N. M. A., Midden, C. J. H., Meijnders, A.L., 2007. Social acceptance of carbon dioxide storage, Energy Policy, 35 (5): 2780-2789

Itaoka, K., Okuda, Y., Saito, A., Akai, M. (2009). Influential information and factors for social acceptance of CCS: the 2nd round survey of public opinion in Japan. Energy Procedia 1, 4803-4810.

Jöreskog, K. G., & Sörbom, D. (2007). LISREL8.80: structural equation modeling with the SIMPLIS command language. Chicago, USA: IL Scientific Software International.

Moser, S.C. (2010). Communicating climate change: history, challenges, process and future directions. Wiley Interdisciplinary Reviews: Climate Change 1: 31–53.

Mueller, R.O. (1996). Basic principles of structural equation modeling: An introduction to LISREL and EQS. New York: Springer-Verlag.

Ping, R. A. (2008). How does one specify and estimate latent variables with only 1 or 2 indicators? [online paper]. http://home.att.net/~rpingjr/Under_Det.doc.

Schumann, D., Simon, A. (2009). Communication of CO2 capture and storage (CCS): Simulating the impact on knowledge and public acceptance. Contributed paper to the Sixth Conference of the European Social Simulation Association, ESSA 2009, University of Surrey, Guildford, September 14-18.